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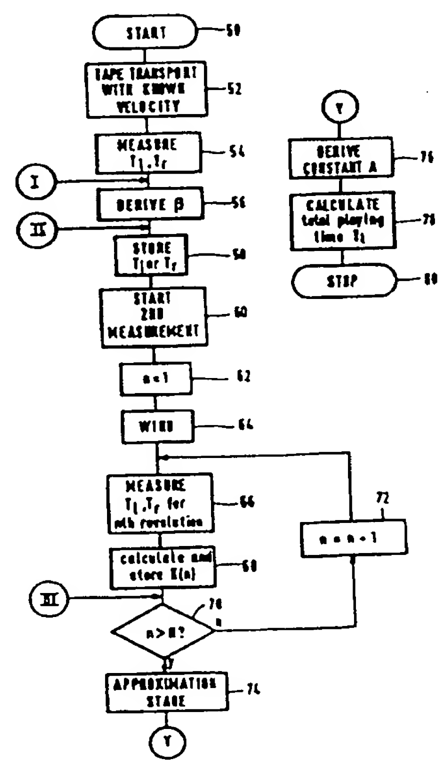
(57) Abstract

A method of and a device for determining the total playing time of a magnetic tape accommodated in a cassette (1) in a magnetic-tape recording and/or reproducing apparatus, for example a video recorder of the helical-scan type. The tape (4) is moved between a tape spool coupled to a first reel disc (2) and a tape spool coupled to a second reel disc (3), two measurements being carried out. In the first measurement the tape is moved with a known tape speed. The revolution times (T_l, T_r) of the first and the second reel disc are measured in this first measurement and a parameter is derived which corresponds to the sum of the squares of the revolution times. A cassette-specific constant (β) is derived from this parameter and the known tape speed. In a second measurement the revolution times of the first and the second reel disc are measured during N revolutions of one of the two reel discs for each revolution of this reel disc. For each revolution a ratio K(n) is calculated from the revolution times thus determined and the cassette-specific constant, K(n) being proportional to $L(n)/L_t$ and L_t being the total length of the tape and L(n) being either the length already used or the residual length of the tape, where n is an integer and $1 \le n \le N$. In an approximation the N calculated ratios K(n) are approximated to by an at least quadratic function in dependence on n and the total playing time is determined from a constant A in the function ($K(n) = X + A.n + B.n^2 + \ldots$) thus obtained.



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Method of and device for determining the total playing time of a tape.

The invention relates to a method of and a device for determining the type of a cassette in a magnetic-tape recording and/or reproducing apparatus, for example a video recorder of the helical-scan type, so as to enable the total playing time of a tape accommodated in the cassette to be determined.

It is to be noted here that the invention is not only of interest for video recorders of the helical-scan type but is suitable in magnetic-tape recording and/or reproducing apparatuses in general, *i.e.* also those of the linear type.

A method of and a device for determining the type of a cassette inserted in a video recorder is known, for example from DE-PS 30 49 296. In that case the sum of revolution times of the take-up spool and the supply spool of the inserted cassette is measured to determine the cassette type, so that the total playing time, the residual playing time and the playing time of the tape already used can be calculated.

In addition, EP 580,253 A2 (PHD 92-092) and the corresponding US Patent Application (serial no.) 08/96,581 (US filing date July 21, 1993) disclose a method and a device in which two measurements are performed to determine the total playing time, where in a first measurement the tape is wound briefly in a threaded-out condition and in a second measurement the tape is moved into a threaded-in condition. In the two measurements the number of pulses produced by the reel discs, which are coupled to the take-up reel and the supply reel of a cassette inserted into an apparatus, and is used to determine the total playing time of the tape.

It is an object of the invention to reduce the inaccuracy in determining the total playing time of the tape and to provide a total playing time measurement which enables the tape length and hence the playing time of the tape to be determined independently of whether the thickness of the tape is known.

To this end a method of determining the total playing time of a magnetic tape accommodated in a cassette in a magnetic-tape recording and/or reproducing apparatus, the tape being moved between a tape spool coupled to a first reel disc and a tape spool

coupled to a second reel disc, at least two measurements being carried out to determine the total playing time of the magnetic tape, is characterised in that first of all a first measurement is carried out while the tape is moved with a known tape speed, and the revolution times of the first and the second reel disc are measured in this first measurement and a parameter is derived which corresponds to the sum of the squares of the revolution times, and in that a cassette-specific constant is derived from this parameter and the known tape speed, in that in a second measurement the revolution times of the first and the second reel disc are measured during N revolutions of one of the reel discs for each revolution of this reel disc, and for each revolution a ratio K(n) is calculated from the revolution times thus determined and the cassette-specific constant, each ratio K(n) being proportional to $L(n)/L_t$ and L_t being the total length of the tape and L(n) being either the length already used or the residual length of the tape, where n is an integer and $1 \leq n \leq N$, in that in an approximation the calculated ratios K(n) are approximated to by an at least quadratic function in dependence on n and the total playing time is determined from a constant A in the function $(K(n) = X + A.n + B.n^2 + \ldots)$ thus obtained.

Thus, the first measurement is performed with known tape speed. In general, this means that the first measurement is performed at the normal reproduction speed.

The essential feature resides in the second measurement. If required, the tape speed during the second measurement may also be the normal reproduction speed. However, the second measurement is preferably carried out at a higher speed in order to minimise the time required for the second measurement. Since the ratio K is calculated for N successive revolutions and these N values for K are approximated to by an at least quadratic function in dependence upon n the total playing time can be determined very accurately without the thickness of the tape being known.

The subsidiary Claims 2 to 8 define advantageous embodiments and variants of the method in accordance with the invention. Claim 8 then defines a method capable of determining whether the inserted cassette is a cassette with small hubs of comparatively small hub diameter or a cassette with large hubs of comparatively large hub diameter. Moreover, Claim 9 defines a method capable of determining whether the inserted cassette is a cassette accommodated in a cassette adapter. Claims 10 to 12 define advantageous embodiments of the method claimed in Claim 9.

Claims 13 to 24 define a device for carrying out the method in accordance with the invention and such a device included in a magnetic tape recording and/or

reproducing apparatus.

Exemplary embodiments of the invention will be described in more detail by means of the following description with reference to the Figures. In the Figures

Figure 1 gives values for the sum of the squares of the revolution times of the reel discs at the standard reproduction speed of the tape for different cassette types,

Figure 2 shows how a ratio K_u varies,

Figure 3 shows diagrammatically a threading device for threading in and threading out a magnetic tape accommodated in a cassette,

Figure 4 shows a first embodiment of a device in accordance with the invention,

Figure 5 shows a first embodiment of the method in accordance with the invention,

Figure 6 shows a modification of the method in Figure 5, for determining whether it concerns a VHS-C cassette,

Figures 7a and 7b show another modification of the method in Figure 5, for determining whether it concerns a cassette with a large hub diameter, and

Figure 8 shows the embodiment of the device in Figure 4 in detailed form.

The description with reference to the Figures is mainly based on the use of the invention in video recorders of the helical-scan type. However, as stated hereinbefore, the field of use is not limited to video recorders and the method in accordance with the invention can also be used in linear recorders for recording and/or reproducing audio and/or video signals in tracks which extend in the longitudinal direction of the tape.

Figure 1 gives for different types of video cassettes the values for the parameter $T_l^2 + T_r^2$, *i.e.* the sum of the squares of the revolution times of the left-hand and the right-hand reel disc of a video recorder at a tape speed in the reproduction or "play" mode. The hatched areas for the different cassette types indicate the variation ranges of the parameter $T_l^2 + T_r^2$. EC30 and EC45 relate to VHS-C cassettes in an adapter, with a total playing time of 30 and 45 minutes, respectively. The cassettes E30, E60 and E90 are cassettes with larger hubs (hub radius approximately 31 mm) and the other cassette types, starting from E105, are cassettes with smaller hubs (hub radius approximately 13 mm).

Figure 1 shows that a detection of the type cassette type based on the

calculation of $T_l^2 + T_r^2$ does not yield unambiguous results because the hatched variation areas for the parameters $T_l^2 + T_r^2$ for different cassette types overlap one another in many cases. For the EC30 and EC45 cassettes this overlapping is caused by the use of adapters. In the other cases overlapping is mainly caused by tolerances in tape thickness.

A reliable determination of the cassette type merely on the basis of the calculation of $T_l^2 + T_r^2$ is therefore not possible.

The method in accordance with the invention for determining the cassette type and hence the total playing time of the cassette is based on the following derivation.

First of all, the following quantities are defined:

R_l	radius of the tape spool on the left-hand reel disc (supply reel disc),
R_r	radius of the tape spool on the right-hand reel disc take-up reel disc),
V	the tape speed,
D	the tape thickness,
L_t	the total tape length,
L_u	the tape length already used,
L_r	the residual length of the tape, *i.e.* the tape length still available,
T_t	the playing time already used,
T_o	the residual playing time, *i.e.* the playing time still available,
T_l	the revolution time of the left-hand reel disc,
T_r	the revolution time of the right-hand reel disc,
R_o	the hub radius of both reel discs.

The following are some basic relationships:

$$L_t.D = R_l^2.\pi + R_r^2.\pi - 2.R_o^2.\pi \quad (1)$$

$$V = 2.\pi.R_l/T_l = 2.\pi.R_r/T_r \quad (2)$$

$$L_u = (R_r^2.\pi - R_o^2.\pi)/D = L_t - L_r \quad (3)$$

$$L_r = (R_l^2.\pi - R_o^2.\pi)/D = L_t - L_u \quad (4)$$

It is possible to derive from these formulas a cassette-specific parameter ß, which complies with:

$$\beta = V^2.(T_l^2 + T_r^2)/4.R_o^2.\pi \quad (5)$$

In a first measurement operation, during which the tape is driven with a known constant tape speed, this parameter β is calculated.

In a threaded-in condition, when the tape pressure roller cooperates with the capstan and the tape is driven, the tape speed V is known, for example in that pulses occurring within a given fixed time interval and supplied by a tachogenerator which cooperates with the capstan are counted. Furthermore, the revolution times of the two reel discs can be measured, for example for example by counting pulses supplied by tachogenerators which cooperate with the reel discs and occurring within a given fixed time interval or by counting clock pulses with a given time spacing, which occur within the revolution time of each reel disc.

When it is now assumed that a cassette with a small hub has been inserted the parameter β can be calculated by means of the formula (5). In addition, the value for the revolution time of the left-hand reel disc or the right-hand reel disc is stored, because this value is required for the evaluation of a second measurement, as will be explained hereinafter.

For the second measurement a ratio K_u or K_r can be derived from the above formulas, which ratio complies with:

$$K_u = T_u/T_t = \{T_l^2.\beta - (T_l^2 + T_r^2)\}/(\beta - 2)(T_l^2 + T_l^2), \quad (6)$$

and

$$K_r = T_o/T_t = \{T_r^2.\beta - (T_l^2 + T_r^2)\}/(\beta - 2)(T_l^2 + T_l^2). \quad (7),$$

respectively,

where $0 \leq K_u,K_r \leq 1$ and $K_u + K_r = 1$.

Figure 2 shows how K_u and, indirectly, also K_r vary in general as a function of the number U of revolutions of a reel disc.

In the present example the tape is driven in a half or fully threaded-out condition during a second measurement operation. The tape is then preferably driven in a direction towards the middle of the tape. This direction can be determined already in the first measurement operation, namely by determining the speeds of rotation of the two reel discs. The tape is preferably driven in a direction towards the middle of the tape because this ensures that the beginning of the tape or the end of the tape will not be reached during the second measurement. In the second measurement operation the tape speed is not relevant because the formulas (6) and (7) are independent of the tape speed.

In the second measurement operation the revolution times T_l and T_r of the two reel discs are measured during N revolutions of one of the reel discs, preferably the reel disc which rotates more slowly, *i.e.* the reel disc coupled to the reel carrying the largest spool of tape in the case of cassettes without adapter, during each revolution of this reel disc. If N revolutions of the left-hand reel disc are used in the second measurement operation the revolution time T_l will be stored beforehand in the first measurement operation.If N revolutions of the right-hand reel disc are used in the second measurement operation the revolution time T_r will be stored beforehand in the first measurement operation.

It is now assumed that in the second measurement operation the ratio k_u for each of these N revolutions of this reel disc is calculated. Thus, N values $K_u(n)$ are calculated, where n is an integer which complies with: $1 \leq n \leq N$. These N values for have been represented diagrammatically in Figure 2. The N values for K_u should be situated on a parabola, *i.e.* on a curve which corresponds to at least a quadratic function. However, as result of influences of measurement techniques or other influences this is not the case with the individual measurements for K_u, for which reason at least some of the N values deviate slightly from the path of the parabola.

For this reason an at least quadratic function representing the parabola is derived from the measured values for K_u which at least partly deviate slightly from the path of a parabola, which is effected by means of an approximation method, for example the least-squares method.

Thus, an approximation step is carried out. In this approximation step the N values for K_u are approximated to by a function K(n). This function is dependent on n and is at least a quadratic function of n. This means that:

$$K(n) = X + A.n + B.n^2 + \ldots.. \quad (8)$$

where X, A and B are constants.

In general, it suffices to approximate to the values for K_u by a quadratic function.

The constants A and V should then be calculated in the approximation step. However, it is particularly the constant A which matters. It can be established that in a first approximation the constant A complies with:

$$A = 2\pi.R/L_t. \quad (9)$$

It is assumed that during the second measurement N revolutions of the left-hand (right-hand) reel disc are measured and R is the radius of the tape spool carried by the left-hand (right-hand) reel disc at the beginning of the second measurement.

This means that:

$$L_t = 2\pi.R/A, \text{ or } T_t = (R/V).2\pi/A. \qquad (10)$$

The radius of the left-hand (right-hand) reel disc at the beginning of the second measurement obviously corresponds to the radius of the left-hand (right-hand) reel disc during the first measurement. The first measurement also complies with:

$$R/V = T_l \text{ (or } T_r).$$

Thus, R/V is equal to the revolution time of the left-hand (right-hand) reel disc in the first measurement. This revolution time has been measured in the first measurement and therefore it can now be used for the calculation of the total playing time of the tape by means of the formula (10), so that the cassette type has thus been detected.

Since the total playing time as well as either K_u or K_r are known it is also possible to calculate the playing time already used and the residual playing time by simply multiplying the total playing time by K_u and K_r (or $1-K_u$).

It has been found that the total playing time thus calculated is very accurate and enables a very reliable detection of the cassette type to be performed. The calculation of the constant A can be achieved by means of a recursive approximation to the tape length. Since recursive approximation methods are well-known from the literature these methods will not be described herein.

It is to be noted that the above described detection method does not function to determine the total playing time of a VHS-C cassette in an adapter. In principle, this is not very important because such adapters are mainly used for playing back a camcorder recording, where the residual playing time is not interesting. Moreover, the above method is not capable of distinguishing between VHS-C cassettes in adapters and cassette types E105 and E120. This is because the variation ranges for these VHS-C cassettes, as indicated in Figure 1, largely if not wholly overlap the variation ranges of the parameters $T_l^2 + T_r^2$ of the cassettes E105 and E120. This problem may arise when it is found in the first measurement that the sum $T_l^2 + T_r^2$ is below a value of, for example, 110, see Figure 1.

This distinction is particularly important for the fast winding mode in order to preclude tape damage at the beginning or end of the tape.

In order to solve this problem of distinguishing between these cassette types the following is to be noted and proposed. Tests have shown that the value of $T_l^2 + T_r^2$ for VHS-C cassettes in adapters is equal to the lower limit of the variation range at the beginning of a the tape, increases during tape transport towards the end of the tape, and reaches the upper limit of the variation range at the end of the tape.

Thus, it appears that in the first measurement operation, when the tape is at its beginning, *i.e.* before the middle of the tape, a reliable distinction can be made between VHS-C cassettes and the types E105 and E120. Indeed, it is possible to select a threshold value, for example equal to the mid value of the variation range of the VHS-C cassettes. The values of $T_l^2 + T_r^2$ for VHS-C cassettes are then always below this threshold value and for the cassette types E105 and E120 they are always above this threshold value.

Thus, it is possible to detect whether the tape is at its beginning, *i.e.* mainly at the supply reel disc, by comparison of the reel-disc tacho-pulses.

Thus, if it is detected that the tape is at its beginning in the first measurement operation and it is furthermore established that the value of the sum of the squares exceeds the threshold value, the second measurement operation can be performe n order to detect whether the cassette of the type E105 or E120. If the sum is below the threshold value the cassette will be of the VHS-C type. The fast winding mode is then inhibited.

If the tape is near the tape end distinction on the basis of the sum of the squares of the revolution times is not possible. Thus, if a value above the threshold value is calculated for this sum in the first measurement operation, the tape must be rewound towards the middle of the tape.If the value of the sum does not change significantly, so that the value remains above the threshold value, the cassette is not of the VHS-C type and the second measurement operation may be carried out. However, if the sum decreases to such an extent that it comes below the threshold value, the cassette will be a VHS-C cassette. The fast winding mode is then inhibited.

It is to be noted that the above steps of determining whether a cassette is a VHS-C cassette and of deciding whether fast winding is allowed can be used both separately and in conjunction with the method of determining the cassette type.

In the description of the first method it has been assumed that a cassette with a small hub has been inserted. However, if in accordance with the standard a cassette of the types E30, E60 and E90 has been inserted this will be a cassette with a large hub. Figure 1 shows that the variation ranges for the sum of the squares of the revolution times for the types E60 and E90 do not overlap the other variation ranges. Thus, if in the first measurement a value for $T_l^2 + T_r^2$ is calculated which exceeds a threshold value of, for example, 160 (see Figure 1), the cassette will be of a type with a large hub and in the calculation of the parameter β in accordance with formula (5) the value for the large hub (31 mm) will be chosen for R_0.

Figure 1 also shows that the variation range of the cassette type E30 partly overlaps the variation ranges of the types E240, E260 and E300. Thus, if during the first measurement a value for the sum of the squares is calculated which is in the range between approximately 140 to 160, it cannot be established whether the cassette is of a type with a large hub or of a type with a small hub. In the first measurement the parameter β is then calculated two times, *i.e.* one time for the small hub and one time for the large hub. In the second measurement K_u(or K_r) is also measured two times for at least one revolution, *i.e.* one time for the one value of β and one time for the other value of β. If now a K value larger than 1 or smaller than zero is obtained on the basis of a large hub, the conclusion may be drawn from this that the cassette is of a type with a small hub. The second measurement can then proceed on the basis of the correct hub diameter thus determined.

In Fig. 3 the numeral 1 refers to a magnetic-tape cassette. The outline of the magnetic-tape cassette is shown diagrammatically as a dash-dot line. A supply reel 2 and a take-up reel 3 are rotatably supported in the magnetic-tape cassette 1. The spool diameter of the tape spool on the supply reel 2 is referenced $2R_l$, the spool diameter of the tape spool on the take-up reel 3 is referenced $2R_r$, and the hub diameter of both reels is $2R_0$. At the location of the cassette mouth 5 the magnetic tape 4 is guided by guide elements 6 and 7.

During a thread-in operation tape-guide elements 8, 9, 10 and 11 engage behind the magnetic tape 4 at the location of the cassette mouth 5, is extracted from the magnetic-tape cassette 1 and is wrapped partly around a drum-shaped scanning device 12. Such tape-threading devices are known *per se* (US Patent 4,807,064) and therefore require no further explanation.

For the transport of the magnetic tape 4 both the supply reel 2 and the take-up reel 3 are, for example, each driven by a winding motor (not shown). The speeds of these winding motors are controlled by means of tacho pulses which are generated by sensing tacho discs. The tacho discs are locked in rotation to shafts of the winding motors.

The block diagram in Fig. 4 shows diagrammatically two tacho discs 13 and 14 of drive motors for the supply reel 2 and the take-up reel 3. It is assumed that the tacho discs are configured to generate for example 400 tacho pulses per revolution by sensing by means of two detectors 15 and 16. The tacho pulses available at an output of the detector 15 are counted by a subsequent counter 17 and the tacho pulses available at an output of the detector 16 are counted by a subsequent counter 18. The counting results at the outputs of the two counters 17, 18 are applied to inputs of a microprocessor 19, which - as will be described in detail hereinafter - computes both the total playing time and the residual playing

time of the magnetic tape 4 on the supply reel 2 and displays the results on a display device 21 after buffering in a memory 20.

Figure 5 is a flow chart of the method carried out by means of the device shown in Figure 4.

The method begins in a block 50. The tape is threaded in and moved with the reproduction speed in a block 52. The tape speed is now known. The revolution times of the left-hand and right-hand reel discs T_l and T_r are measured in a block 54 and from these the value for β is calculated by means of formula (5) in a block 56. Either the value T_l or the value T_r is stored (see block 58), depending on whether N revolutions of the left-hand or the right-hand reel disc are used in the second measurement. At the beginning of the second measurement the tape is returned into the cassette, see block 60. A variable n is set to 1 in a block 62 and the tape transport is switched to fast winding, see the block 64, preferably in a direction towards the middle of the tape.

In a block 66 the revolution times of the two reel discs are measured again and in a block 68 the ratio K(1) is calculated, for example in accordance with the formula (6) or the formula (7), and is stored. This is repeated for N revolutions, see blocks 70 and 72. After the revolution times T_l and T_r have been measured for N revolutions of the left-hand and the right-hand reel disc, respectively, the N calculated ratios K(n) are approximated to by a quadratic function in an approximation step, see block 74. Particularly the value A for the factor of the member of the function which depends on n is then important, which value is derived in a block 76. As stated above, the total playing time T_t of the tape can be calculated from this value, see block 78, and the cassette type has thus been established. If desired, the playing time used or the residual playing time of the tape can also be calculated. The method is stopped in a block 80.

The first measurement is represented by the blocks 52 to 58 and the second measurement is represented by the blocks 66 to 76.

The paths issuing from I, II and III will now be described in conjunction with Figures 6 and 7.

Figure 6 represents a method of determining whether the cassette is a VHS-C cassette in an adapter. The method starts in the blocks 50. The steps in blocks 52 and 54 in Figure 5 are now carried out again. The sum of the squares of the revolution times is calculated in a block 82. This block is shown explicitly in Figure 6. It is obvious that this block is also included Figure 5, namely in block 56 in this Figure. Subsequently, it is determined in a block 84 whether the sum exceeds a first threshold value THR1. In

accordance with the table in Figure 1 this threshold value THR1 is, for example, approximately 110. If this value is exceeded this means that it cannot be a VHS-C cassette. The method then proceeds *via* a block 86. In this block 86 it is for example possible to allow rewinding, because it is certain that the cassette cannot be of the VHS-C type. Another possibility is to switch over the method in accordance with Figure 5 in order to detect the cassette type. The method then proceeds with the step in block 56 in Figure 5.

If the sum is smaller than THR1 the method continues in a block 88. In the block 88 it is ascertained whether the sum exceeds a threshold value THR2. This threshold value THR2 is for example approximately 75 in the table in Figure 1. If this value is not exceeded this means that the cassette is of the VHS-C type. The method then proceeds in a block 90, where rewinding may be inhibited and/or an indication may be given that the cassette is of the VHS-C type. The method then stops in a block 92. If the value of the sum exceeds the second threshold value THR2, the method is continued in a block 94 where the revolution times T_l and T_r are compared with one another. If T_r is smaller than T_l the cassette cannot be a VHS-C cassette but a cassette of either the E105 or E120 type. The method proceeds with the block 86.

If T_r is larger than T_l the cassette is of the VHS-C type and a flag is set, see the block 96. It is again possible to indicate on a display that the cassette is of the VHS-C type. Moreover, the tape transport may be switched off.

As already explained above, the fact that the sum is larger than THR2 and that T_r is larger than T_l means that the tape is in a position beyond the middle of the tape. Therefore, rewinding is allowed. Thus, if a second branch of the method is carried out in a block 98, where a user for example sets the apparatus to fast rewinding, see block 100, the revolution times T_l and T_r are measured again in a block 102. In a block 104 it is detected whether the flag has been set. If this is not the case, the method proceeds in accordance with the branch 101. If the flag has been set it is ascertained whether the tape is in the proximity of its beginning. This can be determined, for example, by a comparison of T_l with T_r. If the tape is at its beginning the method proceeds with block 52. Since the tape is now at its beginning, the comparison in block 88 will yield a negative result, so that fast rewinding is inhibited, block 90. It is to be noted once more that the steps in accordance with Figure 6 may also be carried out separately.

Figures 7a and 7b show an extension of the method in order to determine whether the cassette is a cassette with large hubs. The method again starts in block 50 in Figure 7a. Also in this case the steps in blocks 52 and 54 of Fig. 5 are carried out. The sum

of the squares of the revolution times is calculated again in block 82. Subsequently, it is determined in a block 110 whether the sum is larger than a third threshold value THR3. In the table shown in Figure 1 this threshold value THR1 is approximately 175. If the sum is larger, this means that the cassette can only be of the E60 or E90 type with large hubs. The method now proceeds with a block 112. The calculation of the value β is based on R_o equal to 31 mm and the method continues with a block 114, proceeding with the method in accordance with Figure 5 from step 58.

If the sum is not larger the method proceeds with a block 116. In block 116 it is determined whether the sum is larger than a fourth threshold value THR4. In the table in Figure 1 this threshold value THR4 is, for example, approximately 140. If this threshold value is not exceeded this means that the cassette is of as type with small hubs. The method then proceeds with a block 118. The value for β is calculated on the basis of R_o equal to 13 mm and the method proceeds with block 114. If the value of the sum is larger than the fourth threshold value THR4, the method is continued in a block 120. Now two values for β are calculated, *i.e.* a first value β_1 based on R_o being 13 mm and a second value β_2 based on R_o being 31 mm. The value for T_l or T_r is again stored in block 58 in exactly the same way as in block 58 in Figure 5.

The steps in the blocks 60, 62 and 64 start the second measurement, in exactly the same way as in Figure 5. In block 66' in Figure 7b the revolution times for the first revolution are measured again and in block 68' a first value for K(1), *i.e.* $K_1(1)$, based on β_1 and a second value for K(1), *i.e.* $K_2(1)$, based on β_2 are calculated.

In a block 122 it is determined whether $K_2(1)$ is smaller than 1 or larger than zero. If this is not the case, this means that the cassette is of a type with large hubs. The method then proceeds with a block 124. Now β is assumed to be equal to β_2, $K_2(1)$ is stored as the value for K(1), see block 128, and the method proceeds with a block 132, with the step 70 in Figure 5. In the case of a positive result in block 122 this indicates a cassette a with small hubs. The method then proceeds in a block 126. Now β is assumed to be equal to β_1, $K_1(1)$ is stored as the value for K(1), see block 130, and the method proceeds in block 132, with the step 70 in Figure 5.

Figure 8 shows a more detailed embodiment of the device in Figure 4.

Outputs of the counters 18 and 17 of Figure 4 are coupled to inputs of two units 150 and 152, respectively. These two units are constructed to determine the revolution times T_l and T_r, respectively, of the two reel discs. A unit 154 calculates the sum of the squares of the revolution times from the applied values for T_l and T_r. From this sum

the value for β is calculated in a unit 156 and is subsequently stored in a memory 158. The unit 156 is capable of calculating a first value for β based on the value for the small hub as well as a second value for β based on the value for the large hub, namely in the case that the method described with reference to Figures 7a and 7b takes this path. The unit 158 is then likewise capable of storing these two values for β.

Subsequently, in the second measurement operation the N values for K(n) are calculated in a unit 160 on the basis of the sum of the squares determined for each revolution of N revolutions of the one reel disc and of the value determined for β, and are stored in a memory 162. After this the approximation is performed in an approximation unit 164 and the value for A is derived therefrom. Subsequently, the total playing time T_t is calculated in a unit 166. For this, one of the values T_l or T_r of the first measurement operation is required. To this end, this value has been stored in a memory 168 in the first measurement operation. The total playing time is then displayed on a display device 170.

To control the measurement operations in accordance with Figures 5, 6, 7a and 7b a control unit 172 and two comparators 174 and 176 have been provided. In the comparator 174 the sum of the squares, which is applied to an input 180, is compared with the first to the fourth threshold value, referenced THRi, where i varies from 1 to 4. These threshold values have been stored in the control unit 172 and are applied to an input 178 of the comparator 174 when the blocks 84, 88 and 104 are carried out in the method of Figure 6 and when the blocks 110 and 116 are carried out in the method of Figures 7a and 7b. The comparator 174 produces a control signal at an output 182 depending on the comparison result. This control signal is applied to an input 184 of the control unit 172. The method is further controlled by the control unit 172 on the basis of this control signal.

In the comparator 176 the revolution times are compared with one another to determine in block 94 in Figure 6 whether the tape is or is not in the proximity of the tape end. A control signal is produced at an output 186 and is applied to the control unit 172 for further controlling the method.

It is obvious that the control unit 172 generates further control signals (not shown), for example to control the various elements in the device. The unit 172 generates, for example, control signals for the memories 158 and 162 to control the storage of the one or two values for β and to control the storage of the values for K(n). In addition, the unit generates control signals 190 for controlling the motors for the reel discs and the capstan.

CLAIMS

1. A method of determining the total playing time of a magnetic tape accommodated in a cassette in a magnetic-tape recording and/or reproducing apparatus, the tape being moved between a tape spool coupled to a first reel disc and a tape spool coupled to a second reel disc, at least two measurements being carried out to determine the total playing time of the magnetic tape, characterised in that first of all a first measurement is carried out while the tape is moved with a known tape speed and the revolution times of the first and the second reel disc are measured in this first measurement and a parameter is derived which corresponds to the sum of the squares of the revolution times, and in that a cassette-specific constant is derived from this parameter and the known tape speed, in that in a second measurement the revolution times of the first and the second reel disc are measured during N revolutions of one of the reel discs for each revolution of this reel disc, and for each revolution a ratio K(n) is calculated from the revolution times thus determined and the cassette-specific constant, each ratio K(n) being proportional to $L(n)/L_t$ and L_t being the total length of the tape and L(n) being either the length already used or the residual length of the tape, where n is an integer and $1 \leq n \leq N$, in that in an approximation the calculated ratios K(n) are approximated to by an at least quadratic function in dependence on n and the total playing time is determined from a constant A in the function ($K(n) = X + A.n + B.n^2$ (...) thus obtained.

2. A method as claimed in Claim 1, characterised in that the constant A is equal to the factor of the member in the function which depends on n.

3. A method as claimed in Claim 1, 2 or 3, characterised in that in the second measurement the revolution times of the first and the second reel disc are measured during N revolutions of the reel disc which rotates more slowly for each revolution of this reel disc.

4. A method as claimed in Claim 1, 2 or 3, characterised in that during the second measurement the tape is wound in a direction towards the middle of the tape.

5. A method as claimed in Claim 1, 2, 3 or 4, characterised in that each calculated ratio K(n) corresponds to $L(n)/L_t$ and the playing time already used or the residual playing time of the tape is determined by multiplication of the determined total playing time

by K(n).

6. A method as claimed in any one of the preceding Claims, characterised in that N is larger than 49.

7. A method as claimed in Claim 6, characterised in that N is an odd number.

8. A method as claimed in any one of the preceding Claims, characterised in that to determine whether the inserted cassette is a cassette with hubs of comparatively small hub diameter or comparatively large hub diameter, during the first measurement the sum of the squares is compared with a threshold value, in that when this sum is found to be at one side of the threshold value in the range of values of the sum a first value for the hub diameter of the hubs in the cassette is used for the calculation of the cassette-specific constant, in that if the value of the sum is found to be at the other side of the threshold value two cassette-specific constants are calculated, *i.e.* one for the first value of the hub diameter and one for a second value of the hub diameter, in that in the second measurement the ratio K is also calculated two times for at least one revolution, *i.e.* one time for the one value of the casette-specific constant and one time for the other value of the constant, in that the values of the two calculated cassette-specific constants are compared with a value range, in that the cassette-specific constant relating to comparatively small hubs is used for the second measurement if this constant value is within the value range, and in that the cassette-specific constant relating to comparatively large hubs is used for the second measurement if this constant-value is within the value range.

9. A method of determining whether a cassette inserted into a magnetic-tape recording and/or reproducing apparatus is a cassette accommodated in a cassette adapter, the magnetic tape being moved between a tape spool coupled to a first reel disc and a tape spool coupled to a second reel disc, characterised in that the revolution times of the first and the second reel disc are measured and a parameter is derived which corresponds to the sum of the squares of the revolution times, the value of the parameters is compared with a first and a second threshold value, the first threshold value being larger than the second threshold value, in that the cassette is identified as a cassette not accommodated in a cassette adapter if the value of the parameter is larger than the first threshold value and the cassette is identified as a cassette accommodated in a cassette adapter if the value of the parameter is smaller than the second threshold value, in that if the value of the parameters lies between the two threshold values the cassette can be identified as a cassette accommodated or not accommodated in a cassette adapter by comparing the two revolution times with one another

and, if it is a cassette accommodated in a cassette adapter, a flag is set.

10. A method as claimed in Claim 9, characterised in that when the apparatus is set to rewinding the revolution times of the first and the second reel disc are measured and it is ascertained whether the flag has been set and, if this is the case, it is ascertained whether the tape has been moved beyond the middle of the tape and, if this is the case, the measurement in accordance with Claim 9 is repeated.

11. A method as claimed in Claim 9, characterised in that if the value of the parameter is found to be smaller than the second threshold value fast re-winding is not allowed.

12. A method as claimed in Claim 9, characterised in that if the value of the parameter is found to be larger than the first threshold value the cassette-specific constant is calculated in accordance with the first measurement in the method as claimed in Claim 1 and subsequently the second measurement is carried out.

13. A device for determining the total playing time of a magnetic tape accommodated in a cassette in a magnetic-tape recording and/or reproducing apparatus, the magnetic-tape recording and/or reproducing apparatus comprising

- a first reel disc and a second reel disc which can be coupled to two tape spools onto which the tape has been wound,
- means for moving the magnetic tape,
- means for measuring the revolution times of the reel discs,

characterised in that the device comprises

- means for carrying out a first measurement while the tape is moved with a known tape speed, and
- means for carrying out a second measurement,

in that the means for carrying out the first measurement comprise

- means for deriving a parameter which corresponds to the sum of the squares of the revolution times of the reel discs,
- means for deriving a cassette-specific constant from this parameter and the known tape speed,

in that the means for carrying out the second measurement comprise

- means by which during N revolutions of one of the reel discs for each revolution of this reel disc a ratio $K(n)$ is derivable from the reel-disc revolution times thus determined and the cassette-specific constant, each ratio $K(n)$ being proportional to $L(n)/L_t$ and L_t being the total length of the tape and $L(n)$ being

either the length already used or the residual length of the tape, where n is an integer and $1 \leq n \leq N$,

- approximation means for approximating to the N ratios K(n) by an at least quadratic function in dependence on n, and
- means for determining the total playing time from a constant A in the function $(K(n) = X + A.n + B.n^2 + \ldots)$ thus obtained.

14. A device as claimed in Claim 13, characterised in that the constant A is equal to the factor of the member in the function which depends on n.

15. A device as claimed in Claim 13 or 14, characterised in that the means for carrying out the second measurement comprise means by which the revolution times of the first and the second reel disc are measurable during N revolutions of the reel disc which rotates more slowly for each revolution of this reel disc.

16. A device as claimed in Claim 13, 14 or 15, characterised in that the means for moving the tape are adapted to wind the tape in a direction towards the middle of the tape during the second measurement.

17. A device as claimed in Claim 13, 14, 15 or 16, characterised in that the device in addition comprises means for deriving the playing time already used or the residual playing time of the tape by multiplying the determined total playing time by K(n), which corresponds to $L(n)/L_T$.

18. A device as claimed in any one of the Claims 13 to 17, characterised in that N is larger than 49.

19. A device as claimed in Claim 18, characterised in that N is an odd number.

20. A device as claimed in any one of the Claims 13 to 19, characterised in that to determine whether the inserted cassette is a cassette with hubs of comparatively small hub diameter or comparatively large hub diameter the means for carrying out the first measurement comprise

- comparator means for comparing the value of the sum of the squares of the revolution times with another threshold value, in that the derivation means for deriving the cassette-specific constant are adapted to use a first value for the hub diameter of the hubs of the cassette when this sum is found to be at one side of the other threshold value in the range of values of the sum, and in that the derivation means are adapted to derive two cassette-specific constants for the first value of the hub diameter and for a second value of the hub diameter if the value of the sum is found to be at the other side of the other threshold value,

the derivation means for deriving the ratio K(n) are adapted to calculate the ratio K two times for at least one revolution in the second measurement, *i.e.* one time for the one value of the cassette-specific constant and one time for the other value of the constant, in that the means for carrying out the second measurement further comprise comparator means for comparing the values of the two calculated cassette-specific constants with a value range, and the means for carrying out the second measurement are adapted to use the value of the cassette-specific contant relating to the comparatively small hubs for the second measurement if this value is within the range of values, and to use the value of the cassette-specific constant relating to the comparatively large hubs for the second measurement if this value is within the range of values.

21. A device for determining whether a cassette inserted into a magnetic-tape recording and/or reproducing apparatus is a cassette accommodated in a cassette adapter, the device comprising means for moving the magnetic tape between a tape spool coupled to a first reel disc and a tape spool coupled to a second reel disc, characterised in that the device comprises

- means for measuring the revolution times of the first and the second reel disc and for deriving a parameter which corresponds to the sum of the squares of the revolution times,
- first comparator means for comparing the value of the parameter with a first and a second threshold value, the first threshold value being larger than the second threshold value,
- identification means for identifying the cassette as a cassette not accommodated in a cassette adapter if the value of the parameter is larger than the first threshold value and for identifying the cassette as a cassette accommodated in a cassette adapter if the value of the parameter is smaller than the second threshold value,
- second comparator means for comparing the two revolution times with one another and on the basis of this comparison determining if the cassette is accommodated or is not accommodated in a cassette adapter, and for setting a flag if it is accommodated in a cassette adapter.

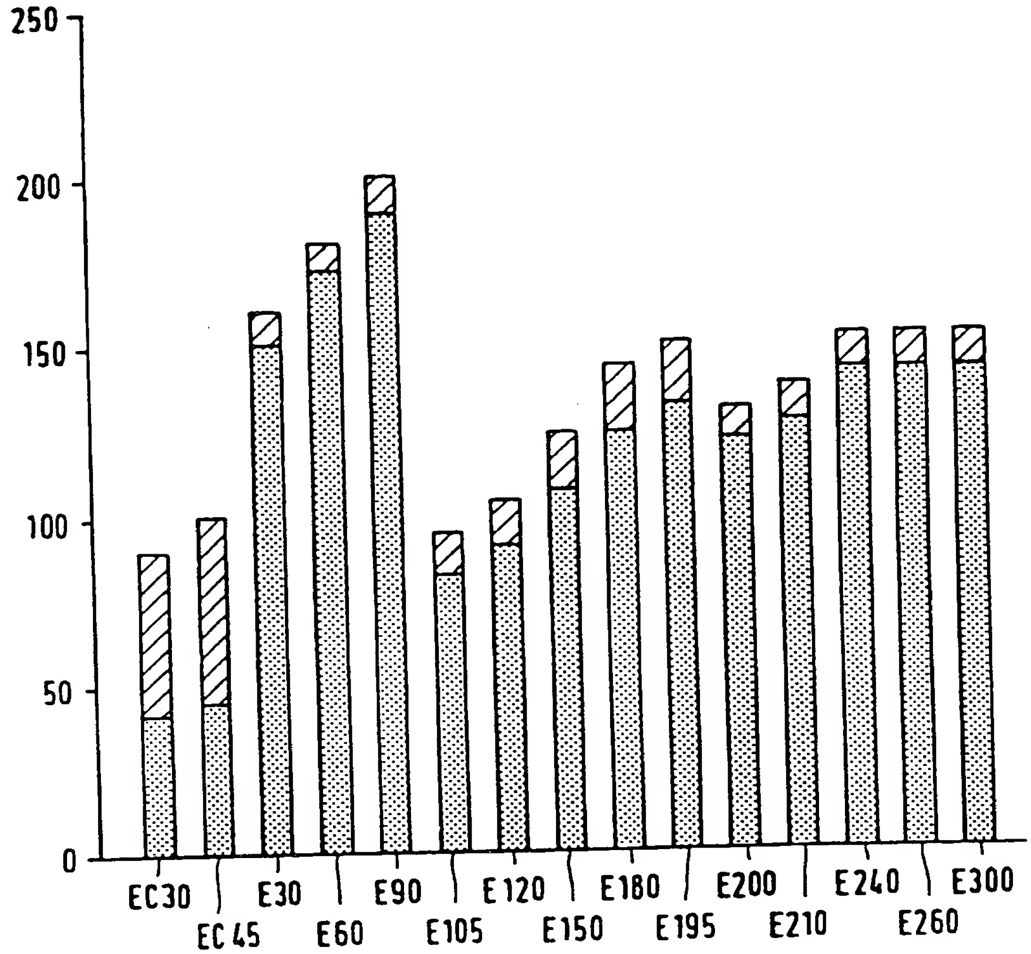
22. A device as claimed in Claim 21, characterised in that the means for measuring the revolution times are adapted to measure again the revolution times of the first and the second reel disc when the apparatus is set to rewinding and detection means have been provided to detect whether the flag has been set and, if this is the case, to detect whether the tape has been moved beyond the middle of the tape and, if this is the case, to carry out another measurement in accordance with Claim 21.

23. A device as claimed in Claim 21, characterised in that means have been

provided to inhibit fast winding if the value of the parameters is found to be smaller than the second threshold value.

24. A device as claimed in Claim 21, characterised in that the device further comprises the means for deriving a cassette-specific constant in accordance with Claim 13 and the means for carrying out the second measurement in accordance with Claim 13, and in that said means are activated if the value of the parameter is found to be larger than the first threshold value.

25. A magnetic-tape recording and/or reproducing apparatus comprising a device as claimed in any one of the Claims 13 to 24.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EC30
EC45
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E240
E260
E300

FIG.1

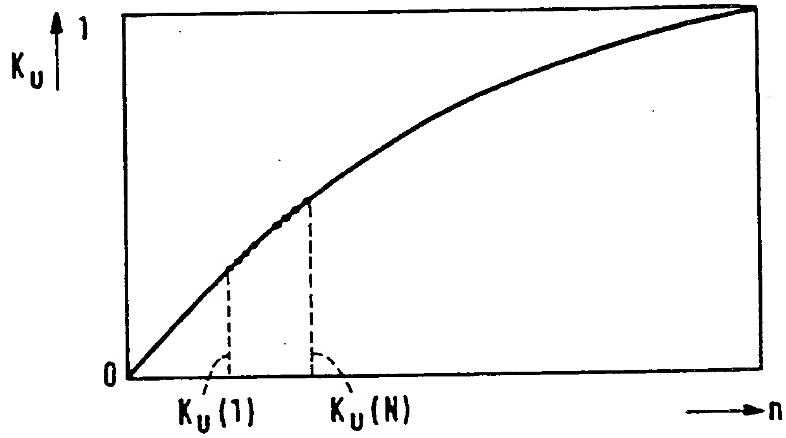


FIG.2

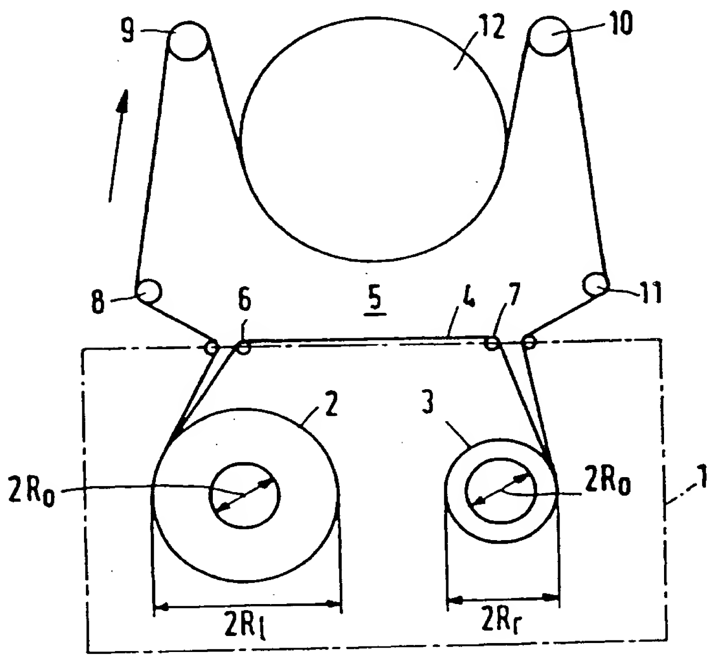


FIG.3

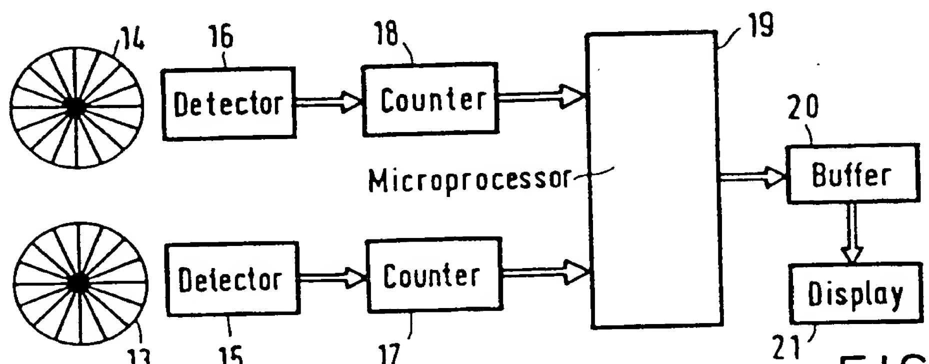


FIG.4

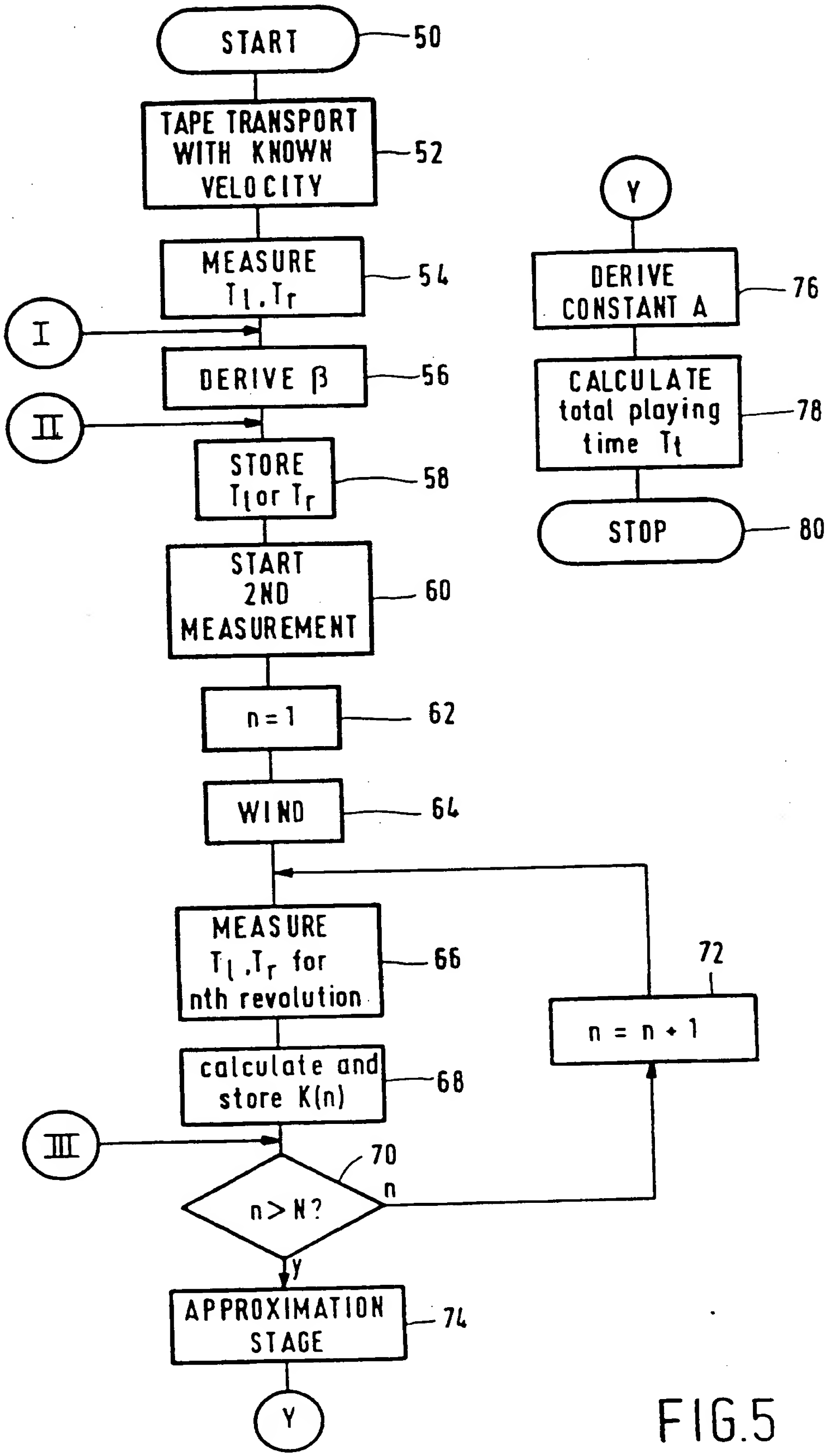
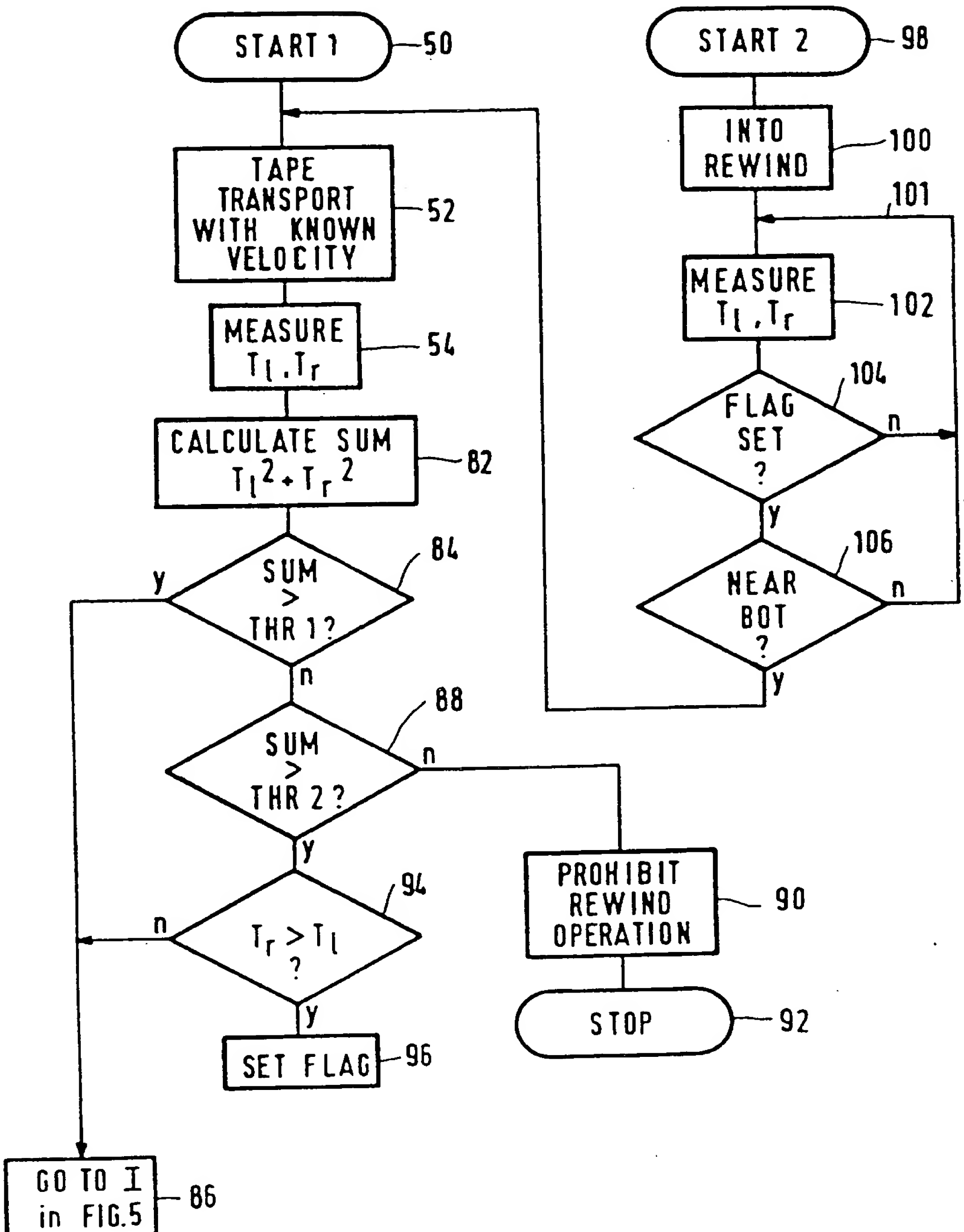

START
50
TAPE TRANSPORT WITH KNOWN VELOCITY
52
MEASURE T_l, T_r
54
I
DERIVE β
56
II
STORE T_l or T_r
58
START 2ND MEASUREMENT
60
n=1
62
WIND
64
MEASURE T_l, T_r for nth revolution
66
calculate and store K(n)
68
III
70
n>N?
n
y
n = n + 1
72
APPROXIMATION STAGE
74
Y
Y
DERIVE CONSTANT A
76
CALCULATE total playing time T_t
78
STOP
80

FIG.5



START 1
50
TAPE TRANSPORT WITH KNOWN VELOCITY
52
MEASURE T_l, T_r
54
CALCULATE SUM $T_l^2 + T_r^2$
82
SUM > THR 1?
84
y
n
SUM > THR 2?
88
y
n
$T_r > T_l$?
94
n
y
SET FLAG
96
GO TO I in FIG.5
86
PROHIBIT REWIND OPERATION
90
STOP
92
START 2
98
INTO REWIND
100
101
MEASURE T_l, T_r
102
FLAG SET ?
104
n
y
NEAR BOT ?
106
n
y

FIG.6

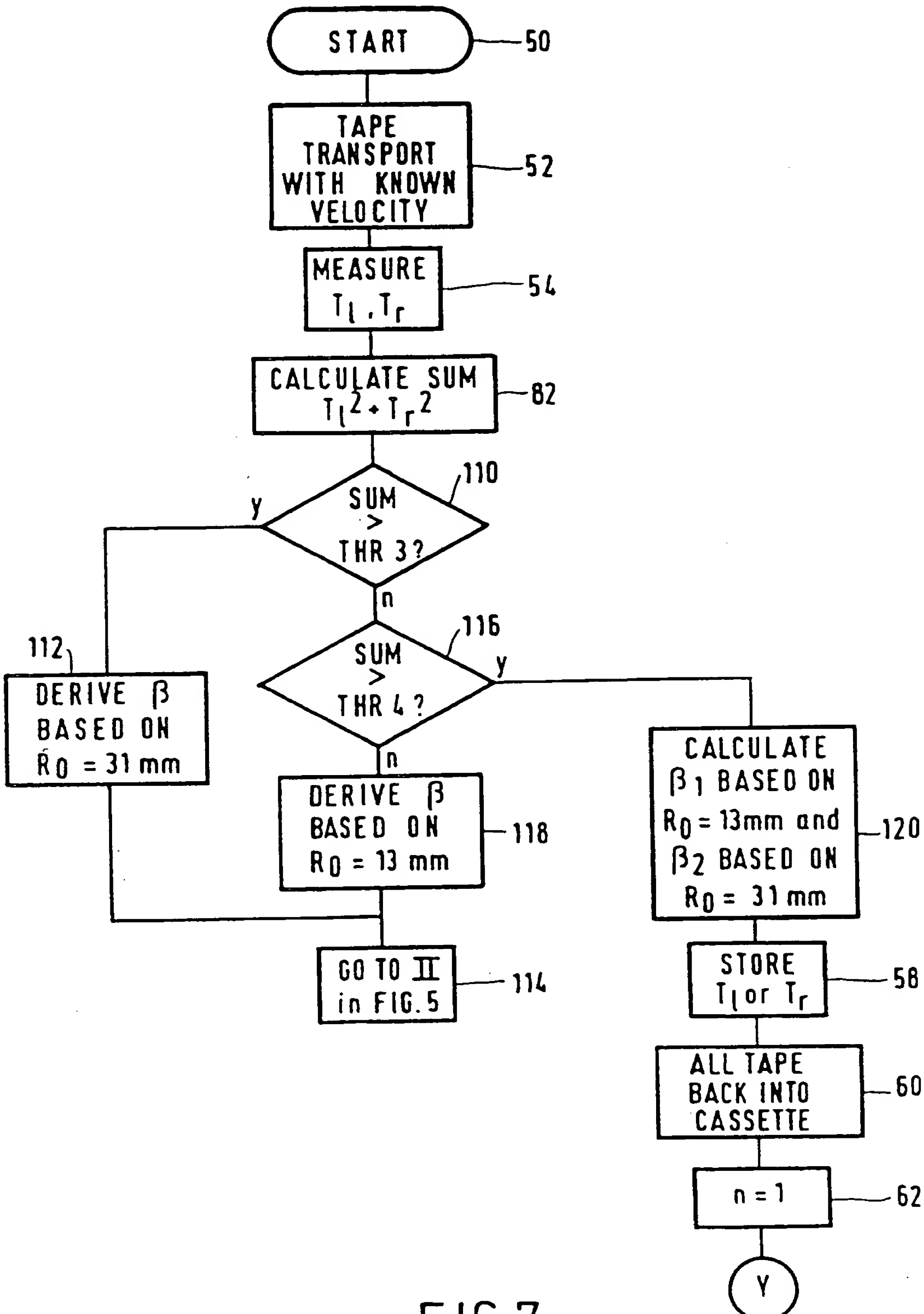

START
50
TAPE TRANSPORT WITH KNOWN VELOCITY
52
MEASURE T_l, T_r
54
CALCULATE SUM $T_l^2 + T_r^2$
82
SUM > THR 3?
110
y
n
SUM > THR 4?
116
y
n
112
DERIVE β BASED ON R_0 = 31 mm
DERIVE β BASED ON R_0 = 13 mm
118
CALCULATE β_1 BASED ON R_0 = 13mm and β_2 BASED ON R_0 = 31 mm
120
GO TO II in FIG. 5
114
STORE T_l or T_r
58
ALL TAPE BACK INTO CASSETTE
60
n = 1
62
Y

FIG.7a

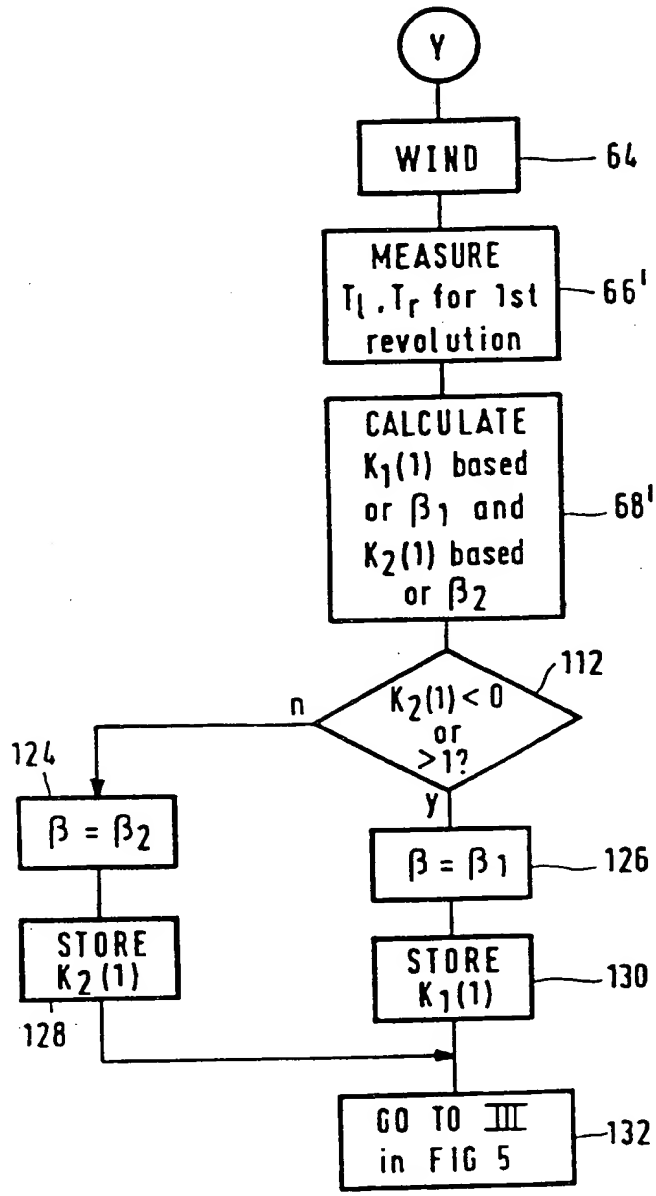

Y
WIND
64
MEASURE
T_l, T_r for 1st
revolution
66'
CALCULATE
$K_1(1)$ based
or β_1 and
$K_2(1)$ based
or β_2
68'
$K_2(1) < 0$
or
>1?
112
n
y
124
$\beta = \beta_2$
$\beta = \beta_1$
126
STORE
$K_2(1)$
128
STORE
$K_1(1)$
130
GO TO III
in FIG 5
132

FIG.7b

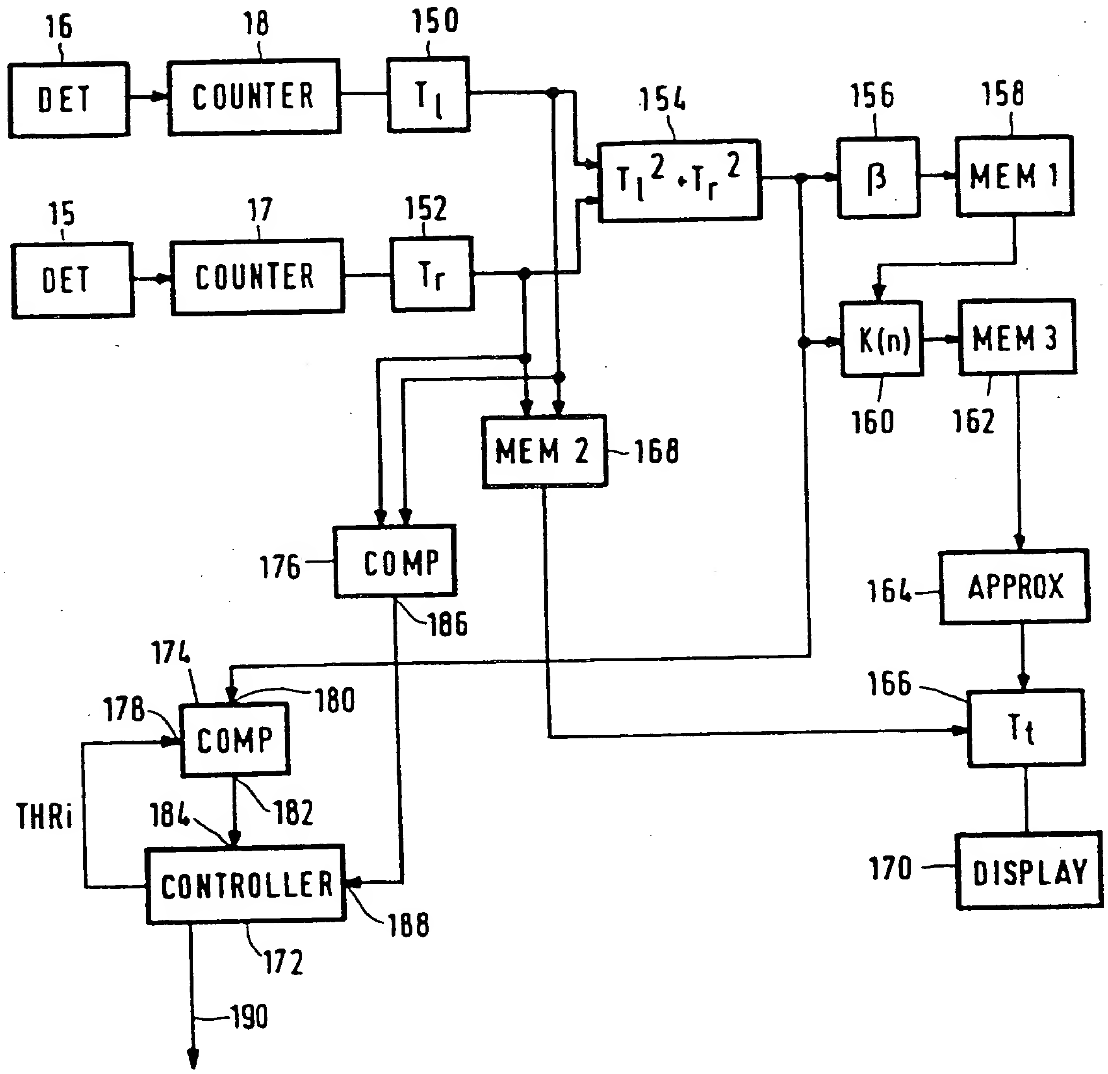

16
DET
18
COUNTER
150
T_l
15
DET
17
COUNTER
152
T_r
154
$T_l^2 + T_r^2$
156
β
158
MEM 1
K(n)
MEM 3
160
162
MEM 2
168
176
COMP
186
164
APPROX
174
178
180
COMP
166
T_t
THRi
184
182
CONTROLLER
188
170
DISPLAY
172
190

FIG.8

INTERNATIONAL SEARCH REPORT

Information on patent family members

05/01/96

International application No.
PCT/IB 95/00829

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 5018040	21/05/91	DE-D,T-	3883467	17/03/94
		EP-A,B-	0308490	29/03/89
		SE-T3-	0308490	
		JP-C-	1852761	21/06/94
		JP-A-	63231786	27/09/88
		US-A-	4938704	03/07/90
		WO-A-	8808627	03/11/88
		WO-A-	9205555	02/04/92
US-A- 4989112	29/01/91	DE-A,C-	3843085	29/06/89
		GB-A,B-	2211651	05/07/89
		JP-A-	1165057	29/06/89
US-A- 4644436	17/02/87	DE-A,C,C	3318324	24/11/83
		GB-A,B-	2122800	18/01/84
		JP-C-	1604612	13/05/91
		JP-A-	58201013	22/11/83
		JP-A-	58201014	22/11/83
		JP-A-	59077690	04/05/84
US-A- 4338645	06/07/82	JP-A-	55062570	12/05/80
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		JP-A-	55064675	15/05/80
		JP-C-	1382543	09/06/87
		JP-A-	55064676	15/05/80
		JP-B-	61049748	30/10/86
US-A- 4280159	21/07/81	AU-B,B-	528820	12/05/83
		AU-A-	4655179	15/11/79
		DE-A,C,C	2918544	15/11/79
		FR-A,B-	2425699	07/12/79
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		JP-C-	1292616	16/12/85
		JP-A-	54145513	13/11/79
		JP-B-	60014430	13/04/85
		NL-A-	7903610	12/11/79

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 95/00829

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 27/13, G11B 27/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5018040 A (NISHIDA), 21 May 1991 (21.05.91) --	1-25
A	US 4989112 A (HAMODA), 29 January 1991 (29.01.91) --	1-25
A	US 4644436 A (UNNO), 17 February 1987 (17.02.87) --	1-25
A	US 4338645 A (MOHRI ET AL), 6 July 1982 (06.07.82) --	1-25
A	US 4280159 A (NAKAYAMA), 21 July 1981 (21.07.81) -- --------	1-25

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" erlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 February 1996	14.02.1996

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Per-Olof Warnbo Telephone No. +46 8 782 25 00